AMENDMENTS TO THE SPECIFICATION

Please amend the paragraphs starting on page 1, line 2 (numbered line 1) and ending on page 9, line 13 with the following:

BACKGROUND

The invention relates to a method of placing at least one component on at least one substrate, wherein the component is picked-up ~~a component being picked up~~ by means of at least a placement machine and placed on a desired position on the substrate. The invention also relates to a system suitable for executing such a method.~~the method as claimed in one of the preceding claims. [sic]~~

~~In such a~~ One such method and system ~~known from United States patent US-A-~~ are disclosed in U.S. Patent No. 5,880,849 in which an image of a substrate is made by a camera. From the ~~image thus made~~ image, a desired position relative to the substrate of a component to be placed on the substrate is established. ~~Then~~ Then, the placement machine is driven and the component is placed on the substrate. By means ~~of the~~ of this method and ~~system known per se~~ system, however, it is ~~not possible to carry out a check to find out~~ impossible to check to see whether the component is really placed on the substrate at the ~~on the~~ desired position.

SUMMARY

An ~~Therefore, it is an~~ object of the present invention to provide a method ~~in which~~ by which the placement of a component on a substrate can be improved in a simple manner.

This object is achieved by the method according to the invention in that after the component has been placed on the substrate, an image of the component placed on the substrate is made by a camera. Any ~~camera, a~~ difference between the actual ~~real~~ position of the component on the substrate and the desired position of the component on the substrate ~~being~~ is then established on the basis of the ~~image, after which~~ image. Subsequently, the positioning of a next component to be placed is adapted to account for any such difference. ~~on account of the difference found.~~

From the image produced by means of the camera, the actual ~~real~~ position of the component relative to the substrate can be determined in a simple manner. Any difference is then established between the desired and actual ~~real~~ positions of the component placed on the substrate. If the component is correctly positioned on the substrate, there will ~~not be any~~ be no substantial difference between the desired and actual ~~real~~ positions of the component on

the substrate. However, if ~~there is~~ a difference ~~indeed~~ exists, in the method according to the invention, the ~~this~~ difference is taken into account by the ~~for the~~ placement machine drive when positioning another ~~a next~~ component ~~is positioned~~ on the substrate. The camera can either form part of the placement machine or form part of a device set up next to or at a distance from the placement machine. Finding the difference between the actual ~~real~~ and desired positions as well as adapting a positioning of a next component based on the difference found, may take place both ~~on line and off line~~ online and/or offline.

According to an embodiment of the method according to the ~~invention is characterized in that~~ present invention, first a same kind of component is placed on a number of substrates ~~on substantially~~ at substantially the same ~~positions, while~~ positions and differences between the desired and actual ~~real~~ positions of the components relative to the associated substrates are ~~determined, the~~ determined. The positioning of a next component to be placed on a next substrate is then ~~being~~ adapted on account of the differences ~~found~~ (if any) identified. In this ~~manner~~ manner, deviations between the desired and actual ~~real~~ positions of the component due to incidental ~~deviations, for example~~ deviations due to what are called stochastic errors ~~such as~~ (e.g., friction in the placement machine, dynamic vibrations, measuring ~~error etc.~~ error, etc.) over a number of substrates are ~~processed when the~~ identified when positioning a subsequent ~~of a next~~ component. However, if an error repeats ~~is adapted and an error remains which will repeat~~ itself at nearly every ~~substrate. This~~ substrate, this error ~~is for example~~ (which may be, e.g., the result of calibration rest errors, the stretching of the substrate due to temperature changes, machine wear, errors in a relatively large number of the same substrates relative to the expected and actual ~~real~~ location ~~of for example~~ of, for example, track patterns on a substrate ~~etc. Errors like these are~~ etc.) is called a deterministic ~~errors.~~ error. When the deviations are ~~processed~~ identified, deviations in substrates that were ~~have already been~~ manufactured earlier are counted less strongly than deviations in a substrate that ~~has been~~ was manufactured just before the substrate now to be provided with components.

According to a further embodiment of the method according to the ~~invention is characterized in that first~~ present invention, first ~~on at least one substrate~~ a number of different components are positioned on at least one substrate. The actual~~, the real~~ positions of ~~which~~ the components are compared ~~with the~~ with desired positions thereof, subsequent to which the positioning of a next component to be placed on the substrate or another substrate is adapted based on a statistically determined average difference. In this ~~way the~~ way, the

differences ~~are determined of~~ may be determined of, for example, ~~example~~ all of the components placed by a certain placement machine.

According to a further embodiment of the method according to the ~~invention is characterized in that~~ present invention, once a number of components have been placed, the ~~real positions are~~ actual positions may be compared with the desired positions. In ~~this way~~ this way, determining the actual ~~real~~ position of the component relative to the substrate can take place independently of the placement of the component on the substrate. A disadvantage of this approach, however, is that not until a number of components have been placed will there be established whether these components have really been positioned ~~on the desired position~~ at the desired positions, thereby creating the desired ~~and only after that will a~~ feedback ~~be realized~~.

According to another embodiment of the method according to the ~~invention is characterized in that~~ present invention, once each component has been placed, the actual ~~real~~ position ~~is compared~~ may be compared with the desired position. In this ~~way there is~~ way, there may be a direct coupling once a component has been placed. If the time for determining the difference between the actual ~~real~~ and desired positions of the component is relatively short, this approach does not have a disadvantageous effect on the time necessary for placing the component.

According to yet another ~~Yet another~~ embodiment of the method according to the ~~invention is characterized in that~~ present invention, components may be placed ~~are placed~~ on at least a substrate by means of a number of placement machines located ~~side by side, each~~ side-by-side. Each placement machine ~~comprising~~ includes, among other possible things, a camera by means of which an image of at least a portion of the substrate is produced to determine the difference between the desired and actual ~~real~~ positions of the component placed on the substrate. In this ~~way it~~ way, it is possible to examine a portion of the substrate by means of each camera, thereby enhancing ~~which enhances~~ accuracy whereas the time required for analyzing each image remains relatively limited.

Another object of the present invention is ~~The invention also has for an object~~ to provide a system with which components can be placed on a substrate more accurately.

This object is achieved with the system according to the ~~invention by the~~ present invention. The system is ~~being~~ provided with at least a placement machine and a camera that cooperates ~~cooperating~~ with the placement ~~machine, an~~ machine. An image of a component positioned on a substrate by means of the placement machine ~~being producible by means of~~ may be produced by the ~~camera, the~~ camera. The placement machine is further ~~being~~

provided with a control scheme by means of which a difference between an actual ~~real~~ position and a desired position of the component relative to the substrate ~~as well as a difference with a desired position of the component relative to the substrate~~ can be determined from the image produced by the camera. In this ~~manner~~ manner, a difference between the actual ~~real~~ position and the desired position of a component on a substrate can be determined in a relatively simple manner. If the placement machine already has a camera, for example, for determining the desired position on the substrate with the camera, an image can be made by the same camera both prior to and subsequent to the placement of the component, i.e., another ~~and no separate~~ camera does not need ~~needs~~ to be added to the placement machine.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only, and are not restrictive of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects, and advantages of the present invention will become apparent from the following description, appended claims, and the accompanying exemplary embodiments shown in the drawings, which are briefly described below.

~~The invention will be further explained with reference to the drawings in which:~~

Figs. 1-5 show plan views of various embodiments of systems according to the ~~invention,~~ invention;

Figs. 6A-6C show plan views of a system according to the invention, the figures showing substrates ~~on the~~ at different ~~positions,~~ positions;

Fig. 7 shows a perspective view of a system according to the ~~invention,~~ invention;

Figs. 8A-8D show different ways of analyzing an ~~image,~~ image;

Fig. 9 shows a control ~~diagram~~ protocol of a method ~~where~~ in which feedback takes place ~~in line,~~ online; and

Fig. 10 shows a control ~~diagram~~ protocol of a method ~~where~~ in which feedback takes place ~~off line~~ offline.

DETAILED DESCRIPTION

Efforts have been made throughout the drawings to use the same or similar reference numerals for the same or like components. ~~Like components in the Figures are denoted by like reference numerals.~~

Fig. 1 shows a system 1 for placing components on a ~~substrate, which~~ substrate. The system 1 comprises three placement machines 2', 2", 2"' located ~~side by side~~ side-by-side.

The substrates to be provided with the components are transported through the system 1 in the direction indicated by arrow Pl by means of a transport system 3. Such a system is ~~known per se from United States patent US A 5,880,849 mentioned above~~ disclosed in previously mentioned U.S. Patent No. 5,880,849 and will, therefore, ~~therefore~~ not be further explained.

Downwards of the system 1 is located ~~a machine~~ a device 4 that has a camera 5 by means of which images of a substrate provided with components can be produced. The images made by the camera 5 are fed to a control ~~diagram~~ protocol 6 (Fig. 9). The positions of components placed on the substrate relative to the substrate are determined by means of the control ~~diagram~~ protocol 6. The control ~~diagram~~ protocol 6 further contains the desired positions 8 in a unit. In element ~~83 the~~ 83, the difference between the desired ~~positions 8~~ positions and the actual ~~real~~ positions, which are stored in a unit 7, is determined ~~by means of the control diagram 6~~. The difference ~~E =) Y~~ $E = \Delta Y$ is subsequently fed to a controller 9 included in the control ~~diagram~~ protocol 6. In the~~, in which~~ controller 9, after filtering by a low-pass filter 10, a feedback signal 12 is calculated by means of a calculation algorithm 11. The feedback signal 12~~, which feedback~~ serves to adjust the control of the individual placement machines 2', 2'', 2'''. The difference E may include both deviations in X, Y and N-direction. This feedback signal 12 may be adjusted per machine. In this ~~way it~~ way, it is possible to increase the accuracy with which a next component is placed on a next substrate. In the embodiment shown in Fig. 1, the ~~systems~~ system 1 and the device ~~4 form separate systems~~ are separate entities.

~~In the embodiment shown in~~ Fig. 2 shows an embodiment in which the ~~machine~~ device 4 is integrated with the system 1 and is installed adjacent to placement machines 2', 2''. The functioning of the system shown in Fig. 2 corresponds to that shown in Fig. 1.

Fig. 3 shows another embodiment of a system 21 according to the invention ~~which~~ that comprises three adjacent placement machines 22', 22'', 22'''. Each of the placement machines 22', 22'', 22''' is ~~which are each~~ provided with an associated camera 23', 23'', 23''' as well as a control ~~diagram~~ protocol belonging to each camera. By means of the system 21 shown in Fig. 3, the ~~3 the~~ deviation between the actual ~~real~~ position of the component and the desired position is determined by means of the camera 23', 23'', 23''' present in the associated machine 22', 22'' and 22''' immediately after the placement of component on a substrate. In ~~this way~~ this way, there is a direct feedback signal 12.

Fig. 4 shows an embodiment of a system 31 according to the invention ~~which~~ that comprises a system 1 shown in Fig. 1, a placement machine 32 installed beside it and a

~~system~~ device 4 installed beside the latter. The operation of the system 31 shown in Fig. 4 corresponds to the system shown in Fig. 1. An advantage of such a system 31 is that not each individual placement machine 2', 2", 2"', 32 needs to have a camera. A disadvantage, however, is that from a substrate on which a component has been placed by means of a placement machine 2', the actual ~~the real~~ positions of the components are not determined by means of the ~~machine~~ device 4 until ~~already~~ a relatively large number of other substrates have been provided with components by placement machine 2'. In ~~this way~~ this way, feedback is relatively slow.

Fig. 5 shows yet another embodiment of a system 41 according to the invention in which a system 42 is installed between the system 1 comprising placement machines 2', 2", 2"' and the ~~system 4, with~~ device 4. With the aid of the ~~which~~ system ~~42 the~~ 42, the component placed on the substrate is affixed to the substrate. Such a system 42, such as, for example a wave soldering device, is known per se and will, therefore, ~~therefore~~ not be further explained. While the component is placed on the substrate, undesired displacements of the components relative to the substrate may occur, which ~~which~~ are not caused by placement inaccuracies.

Figs. ~~6A 6C~~ 6A-6C show the system 21 represented in Fig. 3, in which each placement machine 22', 22", 22"' comprises an associated camera 23', 23", 23"'. This system 21 largely corresponds to the system known from ~~United States patent US-A-5,880,849. In the system shown in that patent~~ U.S. Patent No. 5,880,849, in which the cameras 23', 23", 23"' are used only for determining a desired position of a component on the substrate and not for determining the actual ~~real~~ position of the component on the substrate subsequent to the placement of the component on the substrate.

In the situation shown in Fig. 6A, three substrates 24', 24", 24"' are located in the system 21. For simplicity, the substrates ~~the substrates~~ show both the components ~~25 already~~ 27-29 already placed and the components 25 still to be placed. Once the substrates 24', 24", 24"' have been situated in the placement machines 22', 22", 22"', a pick-up device 26 mounted beside the camera 23' picks up a component from a feeding device (known per se) by the displacement of the pick-up device 26 (and ~~and~~ the camera going with ~~it in~~ it) in the directions shown by the arrows X, Y. Then, ~~Then~~ a desired position ~~on the~~ on a substrate 24"'-24' is determined with the aid of the associated camera 23'-23"'. Subsequently, ~~after which~~ the component is placed on the substrate by means of the pick-up device 26. Then an image of a portion of the substrate 24'-24"' is made by means of the camera ~~23-23"'~~ 23'-23"'. This may be the portion on which a component is placed by means of the respective

placement machine, but it is alternatively possible during the displacement of the pick-up device 26 and the associated camera 23'-23''' to make several substrate images of portions that ~~accommodated components already at an earlier time~~ already contain components. In the situation shown in Fig. 6A, an ~~6A an~~ image of the component 27 on substrate 24" is made by camera 23', an image of the component 28 on substrate 24" is made by camera 23", and an image of the component 29 on substrate 24' is made by camera 23'''.

Then, as shown in Fig. 6B, the substrates 24'-24''' are moved in the direction indicated by arrow P1 after which the substrate 24" is largely located in the placement machine 22''', the substrate 24''' is largely located in the placement machine 22' and partly in the placement machine 22", and a ~~and a~~ new substrate 24'''' is partly located in the placement machine 22'. Subsequently, components are placed on the substrates 24"-24'''' by means of the pick-up devices 26. Subsequently, ~~after which the camera 22'~~ the camera 23' produces an image of the component 51 on substrate 24'''', the camera 23" produces an image of the component 52 on substrate 24''', and the ~~and the~~ camera 23''' produces an image of the component 53 on the substrate 24". As a result, positions ~~Positions~~ of measured components on substrate 24" can be corrected when components are placed on substrate 24'''. This provides a relatively fast feedback.

After the substrates have again been moved in the direction indicated by the arrow PI, the situation shown in Fig. 6C is obtained. In ~~like manner as~~ the manner previously described ~~above~~, a camera 23' produces an image of a component 54 on substrate 24''''', a camera 23" produces an image of a component 55 on substrate 24'''', and a ~~and a~~ camera 23''' produces an image of a component 56 on substrate 24'''.

From the images thus ~~produced can now be established from for example substrate 24'''~~ produced, the actual position of both component 52 and component 56 relative to the substrate 24''' can be established. In the situation shown in Figs. 6A-6C, each ~~each~~ camera produces only one image of a single substrate. Of course, ~~It may be obvious that~~ while the cameras 23"-23''' are moved over a substrate in the XY plane, various images can be produced. By means of a control ~~diagram~~ protocol these images ~~are then~~ may then be combined to create a complete image of a single substrate, thereby providing ~~so that~~ information about the positioning accuracy of a number of components on a substrate ~~can be obtained~~.

Fig. 7 shows a perspective view of a system 61 according to the invention. Although the system 61~~, which~~ largely corresponds to the system shown in ~~Fig. 1 with~~ Fig. 1, a separate, camera-equipped machine 63 is ~~being~~ installed side-by-side ~~side by side~~ with a

placement machine 62. The embodiment shown in ~~This~~ Fig. 7 clearly shows that producing an image of a substrate 24' and determining possible corrections therefrom can only have an effect on a substrate that is located totally on the ~~left~~ left, in the situation shown in ~~Fig. 7,~~ Fig. 7. The system 61, however, does not effect ~~but cannot have an effect on~~ the three substrates 24 situated therebetween. As a result, the feedback signal 12 is relatively slow ~~but does occur~~.

Figs. 8A-8D show a similar image 71 from which~~, however,~~ the desired information, which is dependent ~~can be derived in dependence~~ on the desired positioning accuracy, the desired speed etc., can be derived. In the image 71 shown in Fig. 8A, the ~~8A the~~ arrows 72 indicate that, for ~~from~~ each of the components 25 present on the substrate 24, the actual ~~the real~~ position of the component 25 relative to the substrate 24 is determined. Then, in ~~Then in~~ the control ~~diagram~~ protocol 6 the actual ~~real~~ position of each component 25 is compared with the desired position. Of course, ~~It may be evident that~~ such a process ~~requires~~ may require a relatively large amount of ~~much~~ calculation time in the control ~~diagram~~ protocol 6.

Therefore, it is alternatively possible to determine, as is shown in Fig. 8B, the actual ~~real~~ position relative to the substrate 24 of only a few components 25. The amount of information to be fed to the control ~~diagram~~ protocol 6, which information is shown by means of arrows 73, is considerably smaller than in the situation shown in Fig. 8A. Preferably, ~~Preferably~~ the components 25, whose ~~are then selected whose~~ positioning accuracy has to be relatively great to guarantee a proper functioning of the substrate 24, are then selected.

In the situation shown in Fig. 8C, the ~~8C the~~ arrows 74, 75, 76 indicate that only the actual positions ~~real position~~ of a number of components 25, which ~~is determined which~~ are positioned by means of the placement machines 22', 22", 22"', are determined. In this ~~way it~~ way, it is possible to individually optimize the accuracy of each placement machine 22', 22", 22"' by means of statistics (e.g., an average per placement machine).

In the situation shown in Fig. 8D, the ~~8D the~~ image 71 is obtained from joining images produced by means of separate cameras 23', 23", 23"'. In this ~~way no~~ way, no extra camera is needed to produce the image 71, but use can be made of cameras 23', 23", 23"' already present in the placement machines 22', 22", 22"'. The information 77 obtained from the individual ~~images~~ images, as well as the joint image ~~71 can~~ 71, can be relatively extensive. This method is particularly suitable if the measuring time and processing time is longer than the time necessary for placing a component on a substrate.

It is alternatively possible to produce a number of different images of different regions of different substrates by means of a single camera. Subsequently, ~~from which, subsequently,~~ a joint image ~~is assembled~~ may be assembled from all of the images.

Fig. 9 shows a control ~~diagram~~ protocol 6 of an ~~in-line~~ online situation ~~where~~ in which components are placed on a substrate by means of a system 1. After placement of the components, ~~after which~~ images of the components placed on the substrate are produced by means of ~~a machine~~ the device 4. Information 81 relating to the desired positions of the component on the substrate is fed to the control ~~diagram~~ protocol 6. These desired ~~nominal~~ positions are stored in a unit 8. The desired positions are corrected via the feedback signal 12, after which the value U thus obtained is fed to the placement machines 2', 2", 2"'. These placement machines 2', 2", 2"' are shown by block 82 in the control ~~diagram~~ protocol 6. Components are positioned on the substrates on the basis of this information. Deviations nl owing to, for example, friction, measuring errors, wear and vibrations may then occur. Deterministic errors are part of the placement process~~, for example~~ (e.g., the placement process ~~shows~~ may show adjustment ~~errors~~ errors). Subsequently, images of the component's actual position are produced by the ~~machine~~ device 4. This is shown as block 7 in Fig. 9. During the production of the ~~images deviations n2 occur which~~ images, deviations n2, which may be the result of measuring noise and calibration errors when the camera is positioned over the substrate, may occur. In an adding element 83, the actual ~~83 the real~~ component positions relative to the substrate calculated from the images are compared with the desired component positions relative to the substrate known from unit 8. The resulting difference ~~E =) Y~~ E = ΔY is fed to a low-pass filter 10 and then processed in unit 11, after which a feedback signal 12 is obtained. In adding element ~~84 this~~ 84, this feedback signal 12 is then combined, as previously described ~~above~~, with information 81 with regard to the desired position of components on a substrate.

If a relatively large amount of information is to be processed, which may be ~~which is~~ impossible ~~for example~~ within a period of time necessary for placing components on a substrate, it may be better to ~~it is better to not~~ produce images for detecting deviations between actual ~~real~~ and desired positions of components on a substrate offline rather than online. ~~on line, but off line.~~ This method, as well ~~as well~~ as the control ~~diagram~~ protocol 91 necessary for this method, is shown in Fig. 10. The control ~~diagram~~ protocol 91 largely corresponds with the control ~~diagram~~ protocol 6, which is shown ~~as shown~~ in Fig. 9, except that the device 4 is not installed~~, as shown in Fig. 1,~~ near the system 1. Instead, the device 4 is ~~but is~~ completely separated ~~from it~~ from system 1. For example, the device 4 can ~~The~~

~~device 4 can for example~~ be installed in a separate laboratory. Of course, as a result of ~~It may be obvious that~~ the offline ~~off-line~~ detection of differences between actual ~~real~~ and desired positions of components on a substrate, a relatively large time delay ~~is obtained~~ may result between the moment ~~of placing~~ the components are placed on the substrate and when ~~then the adaptation of~~ the driving of the placement machines is adapted for component placement on a next substrate.

It is alternatively possible to both verify the positions of a limited number of components ~~in line~~ online and verify the positions of all components ~~off line~~ offline.

It is possible to ~~process~~ process, in the algorithm 11, information ~~information~~ of the actual ~~real~~ and desired positions of a specific component as it ~~as it~~ is positioned on a number of substrates. This ~~provides as it were~~ may provide an average over time of the actual ~~real~~ and desired positions by the use of, for example, digital filters.

Given the disclosure of the present invention, one versed in the art would appreciate that there may be other embodiments and modifications within the scope and spirit of the invention. Accordingly, all modifications attainable by one versed in the art from the present disclosure within the scope and spirit of the present invention are to be included as further embodiments of the present invention. The scope of the present invention is to be defined as set forth in the following claims.